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(54) **Process for improving and retaining pulp properties.**

(57) A method is provided for treating pulp fibres, that have already been curled which method comprises: subjecting the pulp to a heat treatment while the pulp is at a high consistency, thereby to render the curl permanent to subsequent mechanical action. This permanent curl has advantages for papermachine runnability and for increasing the t ughness of the finished product.

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3. BACKGROUND OF THE INVENTION

(i) Field of the Invention

This invention relates to a process for treating lignocellulosic pulp fibres of either softwoods or hardwoods to provide pulps of improved properties. In particular this invention is directed to the treatment of mechanical pulps and high-yield chemical pulps to improve and retain the properties of such pulps.

(ii) Description of the Prior Art

Newsprint traditionally has been manufactured from a furnish consisting of a mixture of a mechanical pulp and a chemical pulp. Mechanical pulp is used because it imparts certain desired properties to the furnish: namely, its high light scattering coefficient contributes to paper opacity and allows the use of a thinner sheet; its high oil absorbency improves ink acceptance during printing.

Chemical pulps are used because they impart properties to the furnish which improve its runnability. Runnability refers to properties which allow the wet web to be transported at high speed through the forming, pressing and drying sections of a papermachine and allows the dried paper sheet to be reeled and printed in an acceptable manner. Runnability contributes to papermachine and pressroom efficiency.

It is believed that improved runnability in chemical pulp is due to high wet-web strength and drainage rate. Wet and dry stretch are important because they are believed to contribute to preventing concentrations

breaks. High drainage rates lower the wat r content and are believed to yield a less fragile web.

Mechanical pulps including stone groundwood (SG) and pressurized stone groundwood (PSG) can be made to provide wet stretch but only at the expense of poor drainage. Higher quality mechanical pulps are obtained by manufacture in open discharge refiners, to produce refiner mechanical pulp (RMP) and in pressurized thermomechanical pulp (TMP). Still further upgraded mechanical pulps were provided by chemical pretreatment of the wood chips prior to refining to provide chemi-mechanical pulp (CMP or CTMP).

U.S. Patent 3,446,699 issued May 27, 1965 to Asplund et al. provided a method for producing mechanical and chemimechanical or semichemical pulps from lignocellulose-containing material, in order to provide what was alleged to be improved quality of the fibres with improved defibration.

U.S. Patent 3,558,428 issued Jan. 26, 1971 to Asplund et al. provided a method for manufacturing chemimechanical pulps involving heating and defibrating the same in an atmosphere of vapour at elevated temperatures and under corresponding pressure of the impregnated chips to provide a more rapid and effective impregnation.

U.S. Patent 4,116,758 issued Sept. 26, 1978 to M.J. Ford provid d a process for producing high-yield chemimechanical pulps from woody lignocellulose material by treatment with an aqueous solution of a mixture of sulfite and bisulfite, to provide a pulp which can

be readily defibered by customary mechanical means to provide a pulp having excellent strength characteristics.

Today's papermaker is faced with the problems of decreasing forest resources, an increasing demand for paper products and stringent environmental laws. Low-yield chemical pulps, e.g. sulphite and kraft pulps, contribute highly to such problems.

The fibres of low-yield chemical pulps are known for their desirable dry- and wet-web strength properties. Observations of low-yield chemical fibres in a formed paper sheet indicate that these tend to have a kink and curl which is said to contribute, in an advantageous way, to the papermachine runnability and to certain physical properties. Mechanical pulps lack the desirable strength properties to replace, in whole or in part, low-yield chemical pulps, e.g. kraft or sulphite pulps, in linerboard, newsprint, tissue, printing grades and coated-base grade of paper. Consequently, it has been an aim of the art to improve the physical properties of mechanical and high-yield chemical pulps, so that such improved pulps would be used to replace low-yield chemical pulps.

A number of mechanical devices have been built to produce curled chemical and mechanical fibres in order to improve certain physical properties. Two such mechanical fibre-curling devices are disclosed in H.S. Hill, U.S. Pat. 2,516,384 and E.F. Erikson U.S. Pat. 3,054,532.

H.S. Hill et al. in Tappi, Vol. 33, No. 1, pp.

36-44, 1950, described a "Curlator" designed to produce curled fibres. The process consisted of rolling fibres into bundles at a consistency of around 15%-35%, followed by dispersion. Advantages claimed were higher wet-web stretch, improved drainage, and higher tear strength and stretch of the finished product. These advantages were at the expense of certain other properties, notably tensile strength.

W.B. West in Tappi, Vol. 47, No. 6, pp. 313-317, 1964, describes high consistency disc refining to produce the same action.

D.H. Page in Pulp Paper Mag. Canada, Vol. 67, No. 1, pp. T2-12, 1966, showed that the curl introduced was both at a gross level and at a fine level which he called "microcompressions". Both types of curl were advantageous.

J.H. De Grâce and D.H. Page in Tappi, Vol. 59, No. 7, pp. 98-101, 1976, showed that curl could be produced adventitiously during bleaching of pulps, by the mechanical action of pumps and stirrers at high consistency.

R.P. Kibblewhite and D. Brookes in Appita, Vol. 28, No. 4, pp. 227-231, 1975, claimed that this adventitious curl could have advantages for practical runnability of papermachines.

High-consistency mechanical defibration of wood chips is known to produce curled, kink_d and twisted fibres. Kinked fibres are known to be particularly ffective in developing extensibility in wet webs if the kinks are set in position so that they survive the

action of pumps and agitators at low consistency and retain their kinked and curled state in the formed sheet. This ensures enhancement of the wet-web stretch and certain other physical properties.

A number of chemical treatment methods have been reported to enhance and retain fibre curl in a refined pulp. In one, Canadian Patent No. 1,102,969 issued June 16, 1981 to A.J. Kerr et al., improvement in tearing strength of the pulp is alleged by the treatment of delignified lignocellulosic or cellulose pulp derived from a chemical, semichemical or chemimechanical pulping process at a pressure of at least one atmosphere, with sufficient gaseous ammonia to be taken up by moist pulp in an amount greater than 3% by weight to weight of oven dried pulp.

In another, Canadian Patent No. 1,071,805 issued Feb. 19, 1980 to A.J. Barnet et al., a method of treatment of mechanical wood pulp is provided by cooking the pulp with aqueous sodium sulphite solution containing sufficient alkali to maintain a pH greater than about 3 during the cooking. The cooking was effected at an elevated temperature for a time sufficient to cause reaction with the pulp and to increase the drainage and wet stretch thereof, but for a time insufficient to cause substantial dissolution of liquor from the pulp, and insufficient to result in a pulp yield below about 90%. A minimum concentration of sodium sulphite was 1% since, below 1% sodium sulphite improvements were said to be too small to justify the expense of treatment.

4. DETAILED DESCRIPTION OF THE INVENTION **0096460**

During the process of papermaking, most of the curl in both high-consistency refined mechanical and high-yield sulphit pulp is lost in the subs quent steps of handling at low consistency and high temperatures. This is also taught in the article by H.W.H. Jones in Pulp Paper Mag. Canada, Vol. 67, No. 6, pp. T283-291, 1966. Jones showed that when mechanical pulp fibres which are curled during high consistency refining are subjected to mild mechanical action in dilute suspension at a temperature of around 70°C the curl tends to be removed. The increased tensile and burst strengths produced by removal of curl was seen as advantageous. Thus, curl in such pulps is normally removed in papermachine operation, since during practical papermaking, pulps are always subjected to mild mechanical action in dilute suspension at temperatures of the order of 70°C.

High-yield and ultra high-yield sulphite pulps are used as reinforcing pulps for manufacture of newsprint and other groundwood-containing papers. Although they may be subjected to high-consistency refining, their fibres are in practice substantially straight because the curl introduced in high-consistency refining is lost in subsequent handling.

Thus, we have identified requirements for

a process for imparting and rendering permanent, the physical properties of such mechanical and high-yield chemical pulps in order to improve their papermachine runnability and pressroom effici-

ency, and an object of this invention is to provide improvements in one or more of these respects. There is also described below an example of a non-chemical method of treating higher-yield pulps to improve and retain certain physical properties so that the pulp can be used to replace in whole or in part, the low-yield chemical pulps.

Another example, described below, of a method of the invention, is to render permanent, by non-chemical means, the curl imparted to the fibres of high-consistency mechanically treated, mechanical and high-yield chemical pulps.

The mechanical pulps or high-yield chemical pulps included within the ambit of this invention can be produced by either mechanical defibration of wood, e.g. in stone groundwood (SG), pressurized stone groundwood (PSG), refiner mechanical pulp (RMP) and thermomechanical pulp (TMP) production or by mechanical defibration, at high consistency, followed or preceded by a chemical treatment of wood chips and pulps e.g. in the production of ultra-high-yield sulphite pulps (UHYS, yields in the range 100-85%), high-yield sulphite pulps (HYS) yields in the range 85-65%), chemi-thermomechanical (CTMP), high-yield chemimechanical (CMP), interstage thermomechanical and chemically post-treated mechanical pulp (MPC) or thermomechanical pulps (TMPC).

By a broad aspect of this invention, a method is provided for treating pulps, that have already been curled, which method comprises: subjecting the pulp to a heat treatment while the pulp is at a high consistency in the form of nodules or entangled mass, thereby

to render the curl permanent to subsequent mechanical action.

By another aspect of this invention, a method is provided for treating high-yield or mechanical pulps, that have already been curled by a mechanical action at high consistency, which method comprises: subjecting the pulp to a heat treatment at a temperature of at least 100°C, while the pulp is at a high consistency of at least 15% thereby to render the curl permanent to subsequent mechanical action.

By yet another aspect of this invention, a method is provided for treating high-yield or mechanical pulps, that have already been curled by a high-consistency action, which method comprises: subjecting the pulp to a heat treatment at a temperature of 100°C-170°C for a time varying between 60 minutes and 2 minutes, while the pulp is at a high consistency of 15% to 35%, thereby to render the curl permanent to subsequent mechanical action.

The present invention in its broad aspects is a method which follows the mechanical action that has already made the fibres curly in either mechanical, ultra high-yield or high-yield pulps. Such a mechanical action generally takes place at high consistency (15%-35%), and may typically be a high-consistency disc refining action, e.g. as is generally used in pulp manufacture.

The method of aspects of this invention thus consists of a simple heat treatment of the pulp in the presence of water while it is retained in the form of

nodules or entangled mass at high consistency. The process may involve temperatures above 100°C in which case a pressure vessel is required.

While the invention is not to be limited to any theory, it is believed that the method sets the curl in place either by relief of stresses in the fibre or by a cross-linking mechanism, so that upon subsequent processing during papermaking, the fibres retain their curled form.

This curled form has particular advantages for the properties of the wet web, so that the runnability of the papermachine is improved. In addition, the toughness of the finished product is increased.

In general terms, the method begins with a pulp that has been converted to the curly state by mechanical action at high consistency, and in which the fibres are held in a curly state in the form of nodules or entangled mass. The pulp may be either purely mechanical e.g. stone groundwood, pressurized stone groundwood, refiner mechanical, thermomechanical, or a chemimechanical pulp such as ultra high-yield sulphite pulp or high-yield sulphite pulp. Conversion to a curly state is generally achieved naturally in the high-consistency refining action that is normally used for refiner mechanical, thermomechanical and ultra high-yield sulphite pulp. For stone groundwood, pressurized stone groundwood and high-yield sulphite pulp, it would be necessary to add to the normal processing a step that curls the fibres. This may be for example by use of the "Curlator" or high-consistency disc refining, or

by use of th "Frotapulper" (E.F. Erikson, U.S. Pat. 3,054,532).

The pulp fibres may be lignocellulosic fibres produced by m chanical defibration, or by r fining, or by refining in a disc refiner at high consistency, or by mechanical defibration at high consistency of wood chips, or by mechanical defibration at high consistency of wood chips followed or preceded by a chemical treatment, or by a single stage refining, or after two successive refinings, or between two successive refinings. They may alternatively be pulp fibres commercially produced under the designation of refiner mechanical pulp, pressurized refiner mechanical pump and thermomechanical pulp either from a single stage or two-stage refining, or commercially produced under the designation of ultra high-yield pulps, high-yield pulps, high-yield chemimechanical pulps, interstage thermomechanical pulps and chemically post-treated mechanical or thermomechanical pulps, or may be part of the furnish, e.g. the refined rejects in mechanical pulp production or may be whole pulps.

The method consists of taking the curled pulp at high consistency (say 15-35%) in the form of nodules or entangled mass and subjecting it to heat treatment without appreciable drying of the pulp. The temperature and duration of the heat treatment controls the extent to which the curl in the fibres is rendered permanent, and this may be adjusted to match the advantages sought.

This method may be carried out as a batch method

in a digester or as a continuous method through a steaming tube maintained at high pressure.

The method may also include the step of incorporating a brightening agent during heat treatment, to upgrade the brightness while retaining the improved pulp properties; or the subsequent steps of brightening or bleaching sequences to upgrade the brightness of the pulps while maintaining the improved pulp properties; or indeed may be carried out in brightened pulps thereby also to maintain adequate brightness after heat treatment.

Nowhere in the prior art is there disclosed a process in which a separate and sole heat treatment at high consistency and high temperatures is given to curled fibres in order to achieve the desired changes in the properties of the wood pulp being treated.

Among the advantages of the examples of methods of this invention as described below in setting in fibre curl in high-yield pulps and mechanical pulps is to provide a means of controlling pulp properties in order to impart high wet-web stretch, work-to-rupture and increased drainage rates. In the case of high-yield pulps, in addition to the above wet-web properties, higher dry-sheet tear strength and stretch are also obtained.

Thus, this invention concerns the discovery that when lignocellulosic pulp fibres, that have already been made curly, are heat treated at (a) consistencies from 10% to 35%, (b) temperatures from 100°C to 170°C using steam at corresponding pressures of 5 psig to 105 psig, (c) for a period of time of from 2

minutes to 60 minutes, fibre curl permanently set in place, and the curl is made resistant to removal in subsequent mechanical action experienced by fibres in the papermaking process. The method of aspects of this invention improves drainage, wet-web stretch, wet-web work-to-rupture and dry-sheet tear strength and stretch.

In one variant, the method is to take a pulp that has been made curly by high-consistency (20-35%) refining, and to set in the curl (and perhaps microcompressions) by subjecting it at a high consistency to an elevated temperature (e.g. 110°C - 160°C) for a brief time (e.g. 1 minute to 1 hour). This set-in curl is resistant to removal by the hot disintegration experienced during papermaking. The advantages of such a pulp are: 1. higher wet-web stretch; 2. higher tearing strength; and 3. better drainage.

The method may be a batch process, i.e. if the pulp is placed in a pressure vessel e.g. a closed reaction vessel or digester, or it may be a continuous process e.g. through a steaming tube maintaining high pressures.

The temperature and duration of the heat treatment controls the extent to which the curl in the fibres is rendered permanent, and this may be adjusted to match the advantages sought. Preferred conditions are as follows: temperatures of from above 100° to 170° with corresponding steam pressures of 5 psig to 105 psig and for periods from 2 minutes to 60 minutes.

The treatment according to aspects of this inven-

tion has been observed to render fibre curl permanent including fibre twists, kinks and microcompressions.

Either during or after completion of the heat treatment the pulp may then be brightened in accordance with any of the well-known conventional brightening sequences.

In general, pulp fibres obtained after refining at high consistency are very curly. For mechanical pulps, if a mild disintegration treatment at room temperature is made on these pulps, the fibres retain substantially their curliness so as to produce wet webs with high wet-web stretch, work-to-rupture and fast drainage. However, in the papermaking process, pulps receive mechanical action at high temperatures and low consistencies so that their curliness is lost. It is believed that pulps which are given standard hot disintegration treatment in the laboratory at low consistency experience similar conditions during which the curliness is lost and the wet-web properties deteriorate.

The following examples are given to illustrate more clearly various embodiments of the invention. In the following examples, the tests were conducted in the following standard way:

Wet-web results were obtained following the procedure described by R.S. Seth, M.C. Barbe, J.C.R. Williams and D.H. Page in Tappi, Vol. 65, No. 3, pp. 135-138, 1982.

Wet-web percent solids, tensile strength, stretch and work-to-rupture were obtained on webs prepared by

applying 0.7 kPa and 103 kPa wet-pressing pressures.

Th percent stretch-to-break was obtained for wet-w bs press d so as to giv a breaking length of 100 meters. It is considered that this value is a measure of the "toughness" of the wet-web and is an indication of the runnability of the pulp on a papermachine.

Changes in drainage rates are given by the measure of Canadian Standard Freeness.

Hot disintegration was done according to the procedure of C.W. Skeet and R.S. Allan in Pulp Paper Mag. Canada, Vol. 69, No. 8, pp. T222-224, April 19,1968.

The extent of fibre curliness has been quantified by an Image Analysis method as described by B.D. Jordan and D.H. Page in the Proceedings of the TAPPI International Paper Physics Conference, Harrison Hot Springs, B.C. (1979). High values of curl indices reflect curlier fibres.

In the examples following, two parameters have been used to follow the progress of the heat treatment effect.

First the curliness of the fibres has been measured, after a standard hot disintegration treatment at low consistency, that simulates the subsequent treatment that the pulp will receive in the papermaking process.

Secondly, the advantage of this new pulp (after hot disintegration) has be n determined in terms of the ext nsibility (percent stretch-to-break) of wet webs prepared from the pulp press d so as to give a br aking length of 100 metres. It is considered that this value

is a measure of the "toughness" of the wet sheet and is an indication of the runnability of the pulp on a papermachine.

EXAMPLE 1

This example is intended to illustrate that when pulp fibres are given a heat treatment, as described for aspects of this invention, they remain curly even after standard hot disintegration.

In this example pulp fibres were treated in a digester at 150°C and at about 22% consistency for approximately 60 minutes.

The results obtained after the above treatments on a variety of mechanical, chemimechanical and chemical wood pulp fibres are reproduced below in Table I.

From the results, it is seen that the heat treatment produces the desired effects, on wet-web stretch and drainage, for all the lignocellulosic pulp fibres, e.g., mechanical pulp and high-yield sulphite pulp fibres. The treatment has no effect on cellulosic pulp fibres which contain little or no lignin.

EXAMPLE 2

This example illustrates the effect of the temperature of the treatment.

Lignocellulosic pulp fibres were treated in a digester at temperatures of 110, 130, 150 and 170°C for 60 minutes and at approximately 22% consistency. The results reproduced in Table II were obtained after a standard hot disintegration.

TABLE I (Sheet 1)

THE EFFECT OF THE HEAT TREATMENT (150°C, 22% CONSISTENCY, 60 MINUTES) ON A VARIETY OF MECHANICAL, CHEMI-MECHANICAL AND CHEMICAL WOOD PULP FIBRES

		SC[1]		PSG[1]		RMP[2]	
Pulp and Fibre Properties		Untreated	Heat Treated	Untreated	Heat Treated	Untreated	Heat Treated
	Curl Index	0.180	0.204	0.163	0.203	0.143	0.258
	CSF (ml)	61	60	48	47	159	248
Wet-Web Properties							
0.7 kPa	Solids (%)	17.8	14.5	15.7	14.7	18.3	19.2
	Tensile (m)	47.7	48.8	63.7	65.3	60.6	48.0
	Stretch (%)	7.05	11.7	8.91	12.8	5.05	11.3
	Work to Rupture (mJ/g)	39.7	62.7	70.4	105	38.3	58.3
103 kPa	Solids (%)	20.2	20.4	24.4	20.5	24.8	24.2
	Tensile (m)	96.1	101	133	124	117	80.5
	Stretch (%)	7.13	9.45	8.26	11.3	4.85	9.19
	Work to Rupture (mJ/g)	77.4	110	131	177	73.5	84.3
Wet-Web Stretch at 100 m Breaking Length (%)		6.29	8.49	8.16	11.4	4.50	7.64

1 Commercial samples
2 Refined at 6.75 MJ/kg and 17% consistency

TABLE 1 (Sheet 2)

THE EFFECT OF THE HEAT TREATMENT (150°C, 22% CONSISTENCY, 60 MINUTES) ON A VARIETY OF MECHANICAL, CHEMI-MECHANICAL AND CHEMICAL WOOD PULP FIBRES

		TMP[3]		TMPC[4] (94% yield)		(90% yield)[5]	
Pulp and Fibre Properties		Untreated	Heat Treated	Untreated	Heat Treated	Untreated	Heat Treated
	Curl Index	0.121	0.239	0.182	0.229	0.102	0.220
	CSF (ml)	181	287	208	221	256	340
Wet-Web Properties							
0.7 kPa	Solids (%)	18.9	18.4	20.8	17.1	22.7	17.3
	Tensile (m)	91.5	60.5	122	74.1	72.6	59.3
	Stretch (%)	6.32	18.6	8.83	20.8	4.15	13.2
	Work to Rupture (mJ/g)	69.0	124	129	203	35.7	90.5
103 kPa	Solids (%)	25.6	22.5	27.2	22.8	29.7	23.4
	Tensile (m)	161	105	207	125	134	114
	Stretch (%)	4.82	14.9	5.68	16.3	3.24	7.08
	Work to Rupture (mJ/g)	90.8	201	136	272	48.9	95.3
Wet-Web Stretch at 100 m Breaking Length (%)		5.90	16.9	7.38	18.2	3.53	8.54

3 Refined at 8.09 MJ/kg and 30% consistency after second stage
4 Pulp (3); cooked to 94% yield by sodium-base sulphite liquor at 10% consistency
5 Refined at 7.60 MJ/kg and 17% consistency

TABLE I (Sheet 3)

THE EFFECT OF THE HEAT TREATMENT (150°C, 22% CONSISTENCY, 60 MINUTES) ON A VARIETY OF MECHANICAL, CHEMI-MECHANICAL AND CHEMICAL WOOD PULP FIBRES

Pulp and Fibre Properties	SULPHITE PULPS (78% yield)[6] Untreated	SULPHITE PULPS (78% yield)[6] Heat Treated	SULPHITE PULPS (70% yield)[7] Untreated	SULPHITE PULPS (70% yield)[7] Heat Treated	SULPHITE PULPS (50% yield)[8] Untreated	SULPHITE PULPS (50% yield)[8] Heat Treated	KRAFT PULP (50% yield)[8] Untreated	KRAFT PULP (50% yield)[8] Heat Tr ated
Curl Index	0.169	0.220	0.148	0.216	0.236	0.285	0.208	0.254
CSF (ml)	236	326	673	624	654	691	675	709
Wet-Web Properties								
.7 kPa Solids (%)	20.6	19.2	26.1	21.5	27.4	27.2	27.5	34.3
Tensile (m)	144	111	82.8	84.1	97.8	64.6	96.9	61.5
Stretch (%)	6.38	16.2	2.38	9.79	21.5	25.5	15.8	17.8
Work to Rupture (mJ/g)	116	244	20.3	110	234	170	174	125
3 kPa Solids (%)	28.3	24.6	29.1	29.2	30.0	32.0	32.0	38.7
Tensile (m)	283	183	143	145	120	82.3	122	77.7
Stretch (%)	5.04	12.3	1.95	5.88	17.5	22.3	9.87	11.6
Work to Rupture (mJ/g)	162	286	27.3	94.6	241	196	129	96.1
t-Web Stretch at) m Breaking Length (%)	8.0	17.7	2.23	8.05	20.1	19.0	13.5	9.[illegible]

efined at 2.20 MJ/kg and 17% consistency
fined at 0.57 MJ/kg and 9% consistency
urlated in a mixer for 2.5 hours at 20% consistency

TABLE II (Sheet 1)

THE EFFECT OF THE TEMPERATURE OF THE TREATMENT

Treatment Temperature (°C)		Untreated	Refiner Mechanical[1] Pulp 110	130	150	170
Pulp and Fibre Properties						
	Curl Index	0.143	0.178	0.225	0.258	0.259
	CSF (ml)	159	207	259	248	231
Wet-Web Properties						
0.7 kPa	Solids (%)	18.3	18.2	23.2	19.2	18.0
	Tensile (m)	60.6	62.4	65.5	48.0	50.7
	Stretch (%)	5.05	7.73	7.28	11.3	12.5
	Work to Rupture (mJ/g)	38.3	45.8	58.5	58.3	77.7
103 kPa	Solids (%)	24.8	23.2	25.0	24.2	22.1
	Tensile (m)	117	104	93.4	80.5	80.7
	Stretch (%)	4.85	5.62	6.75	9.19	10.4
	Work to Rupture (mJ/g)	73.5	69.8	75.7	84.3	100
Wet-Web Stretch at 100 m Breaking Length (%)		4.50	5.86	6.50	7.64	9.52

[1] Refined at 6.75 MJ/kg and 17% consistency

TABLE II (Sheet 2)

THE EFFECT OF THE TEMPERATURE OF THE TREATMENT

Treatment Temperature (°C)		Untreated	Thermomechanical[2] Pulp 110	130	150	170
Pulp and Fibre Properties						
	Curl Index	0.121	0.138	0.180	0.239	0.261
	CSF (ml)	181	244	292	287	284
Wet-Web Properties						
0.7 kPa	Solids (%)	18.9	18.6	18.6	18.4	19.4
	Tensile (m)	91.5	85.5	75.4	60.5	56.4
	Stretch (%)	6.32	8.61	13.0	18.6	19.6
	Work to Rupture (mJ/g)	69.0	88.9	114	124	143
103 kPa	Solids (%)	25.6	23.4	22.7	22.5	23.6
	Tensile (m)	161	147	117	105	88.5
	Stretch (%)	4.82	6.87	11.1	14.9	18.8
	Work to Rupture (mJ/g)	90.8	119	187	201	216
Wet-Web Stretch at 100 m Breaking Length (%)		5.90	8.13	12.7	16.9	18.0

[2] Refined at 8.09 MJ/kg and pulp at 30% consistency after second stage refining

TABLE II (Sheet 3)

THE EFFECT OF THE TEMPERATURE OF THE TREATMENT

			High-Yield Sulphite Pulp (90% yield)[3]			
Treatment Temperature (°C)		Untreated	110	130	150	170
Pulp and Fibre Properties						
Curl Index		0.153	0.166	0.206	0.226	0.221
CSF (ml)		279	292	358	287	269
Wet-Web Properties						
0.7 kPa	Solids (%)	20.5	22.5	20.8	19.2	17.3
	Tensile (m)	73.3	74.5	60.2	63.0	72.1
	Stretch (%)	5.45	6.51	11.1	15.8	14.9
	Work to Rupture (mJ/g)	49.0	71.9	97.9	107	137
103 kPa	Solids (%)	24.9	26.5	23.9	23.4	21.8
	Tensile (m)	118	107	97.6	101	120
	Stretch (%)	4.02	5.42	7.82	11.1	11.2
	Work to Rupture (mJ/g)	56.7	76.0	110	143	157
Wet-Web Stretch at 100 m Breaking Length (%)		4.61	5.54	7.96	10.9	12.5

[3] Refined at 7.60 MJ/kg and 17% consistency

TABLE II (Sheet 4)

THE EFFECT OF THE TEMPERATURE OF THE TREATMENT

Treatment Temperature (°C)		Untreated	High-Yield Sulphite Pulp (70% yield)[4] 110	130	150	170
Pulp and Fibre Properties						
Curl Index		0.147	0.181	0.217	0.237	0.239
CSF (ml)		685	692	675	601	648
Wet-Web Properties						
0.7 kPa	Solids (%)	27.4	27.3	26.3	24.3	25.9
	Tensile (m)	74.0	75.8	76.5	91.6	68.5
	Stretch (%)	2.10	4.07	8.81	17.8	5.04
	Work to Rupture (mJ/g)	16.2	32.1	93.7	189	38.4
103 kPa	Solids (%)	31.1	31.1	30.3	28.6	30.7
	Tensile (m)	124	121	108	124	117
	Stretch (%)	2.00	3.37	5.06	12.2	3.75
	Work to Rupture (mJ/g)	26.3	39.4	73.9	203	49.7
Wet-Web Stretch at 100 m Breaking Length (%)		2.21	3.72	6.23	15.3	4.04

[4] Refined at 0.64 MJ/kg and 30% consistency

EXAMPLE 3

This example illustrates the effect of the time for the treatment.

Lignocellulosic pulp fibres at approximately 22% consistency were treated in a digester at 150°C for 2, 10 and 60 minutes respectively. The results reproduced in Table III were obtained after a standard hot disintegration.

It can be seen that the time, as well as the temperature (Example 2), control the extent to which the curl in the fibres is rendered permanent. Both variables can be adjusted to yield pulp with the required properties sought.

In addition to the time to maintain the desired properties of curly fibres and temperature of the treatment described above, the extent to which fibre curl is present, after heat treatment and hot disintegration also depends on the state of the fibres immediately after refining. In Table III it can be seen that for two 70%-yield sulphite pulps, the one refined at 30% consistency, i.e., containing more curly fibres, will require a shorter heat treatment and/or a treatment at a lower temperature to achieve the same wet-web strength properties as that for the pulp refined at 9% consistency.

EXAMPLE 4

This example illustrates the effect of the consistency of the pulp fibres when submitted to heat treatment.

TABLE III (Sheet 1)

THE EFFECT OF THE TIME FOR THE TREATMENT

			Refiner Mechanical Pulp[1]				Thermomechanical Pulp[2]		
Time for Treatment (minutes)		Untreated	2	10	60	Untreated	2	10	60
Pulp and Fibre Properties									
	Curl Index	0.143	0.189	0.210	0.258	0.121	0.152	0.168	0.239
	CSF (ml)	159	214	206	248	181	200	225	287
Wet-Web Properties									
0.7 kPa	Solids (%)	18.3	20.5	17.9	19.2	18.9	20.8	20.5	18.4
	Tensile (m)	60.6	57.4	58.8	48.0	91.5	78.4	80.1	60.5
	Stretch (%)	5.05	7.73	9.83	11.3	6.32	8.82	11.2	18.6
	Work to Rupture (mJ/g)	38.3	54.5	63.5	58.3	69.0	89.5	112	124
103 kPa	Solids (%)	24.8	27.5	23.0	24.2	25.6	26.1	27.0	22.5
	Tensile (m)	117	107	97.2	80.5	161	125	135	105
	Stretch (%)	4.85	5.17	7.51	9.19	4.82	6.57	7.79	14.9
	Work to Rupture (mJ/g)	73.5	66.1	83.1	84.3	90.8	115	135	201
Wet-Web Stretch at 100 m Breaking Length (%)		4.50	5.32	7.66	7.64	5.90	7.62	9.53	16.9

[1] Refined at 6.75 MJ/kg and 17% consistency
[2] Refined at 8.09 MJ/kg and 30% consistency

TABLE III (Sheet 2)

THE EFFECT OF THE TIME FOR THE TREATMENT

		High-Yield Sulphite Pulp[3] (90% yield)				High-Yield Sulphite Pulp[4] (70% yield)			
Time for Treatment (minutes)		Untreated	2	10	60	Untreated	2	10	60
Pulp and Fibre Properties									
	Curl Index	0.102	0.178	0.179	0.220	0.148	0.155	0.218	0.216
	CSF (ml)	256	294	363	340	673	674	694	624
Wet-Web Properties									
0.7 kPa	Solids (%)	22.7	20.4	18.5	17.3	26.1	28.1	25.0	21.5
	Tensile (m)	72.6	57.1	47.1	59.3	82.8	86.2	71.5	84.1
	Stretch (%)	4.15	7.48	9.57	13.2	2.38	2.57	4.84	9.79
	Work to Rupture (mJ/g)	35.7	56.5	57.8	90.5	20.3	23.5	40.3	110
103 kPa	Solids (%)	29.7	25.0	24.5	23.4	29.1	31.0	31.5	29.2
	Tensile (m)	134	100	95.4	114.	143	124	130	145
	Stretch (%)	3.24	5.04	6.17	7.08	1.95	2.23	3.40	5.88
	Work to Rupture (mJ/g)	48.9	69.1	72.6	95.2	27.3	28.4	49.5	94.6
Wet-Web Stretch at 100 m Breaking Length (%)		3.53	5.17	6.01	8.54	2.23	2.36	3.76	8.05

3 R fined at 7.60 MJ/kg and 17% consistency
4 Refined at 0.57 MJ/kg and 9% consistency

TABLE III (Sheet 3)

THE EFFECT OF THE TIME FOR THE TREATMENT

			High-Yield Sulphite Pulp[5] (70% Yield)		
Time for Treatment (minutes)		Untreated	2	10	60
Pulp and Fibre Properties					
	Curl Index	0.147	0.187	0.214	0.237
	CSF (ml)	685	698	678	601
Wet-Web Properties					
0.7 kPa	Solids (%)	27.4	24.6	24.5	24.3
	Tensile (m)	74.0	51.5	91.4	91.6
	Stretch (%)	2.10	6.11	18.3	17.8
	Work to Rupture (mJ/g)	16.2	35.2	201	189
103 kPa	Solids (%)	31.1	30.0	31.0	28.6
	Tensile (m)	124	94.4	150	124
	Stretch (%)	2.00	4.15	9.97	12.2
	Work to Rupture (mJ/g)	26.3	45.2	158	203
Wet-Web Stretch at 100 m Breaking Length (%)		2.21	4.31	16.5	15.3

5 Refined at 0.64 MJ/kg and 30% consistency

Lignocellulosic pulp fibres were treated in a digester at 150°C for 60 minutes at consistencies of 5, 10, 20, and 25%. For the purposes of this specification, the term "% consistency" means the percentage of oven-dried weight of pulp fibres to the total weight of pulp fibres plus water. The results reproduced in Table IV were obtained after a standard hot disintegration.

The effect of the treatment is greater, the higher the consistency of the pulp fibres. The treatment has no effect on pulp fibres at low consistency, typically lower than 5%.

EXAMPLE 5

This example illustrates the effect of the heat treatment on the wet-web and dry-handsheet properties of high-yield pulps.

The lignocellulosic pulp fibres were heat treated in a digester at 150°C and at about 20% consistency for approximately 60 minutes. For the pulp fibres, in the high-yield range, the heat treatment improves, in addition to the wet-web stretch and work to rupture, the dry handsheet tear strength and stretch (Table V).

EXAMPLE 6

This example illustrates the effect of the pH of the pulp fibres during the heat treatment. A 70% yield sulphite pulp at a pH of 3.2 was heat treated in a digester at 150°C and at about 20% consistency for approximately 60 minutes. Another sample of the same

TABLE IV (Sheet 1)

THE EFFECT OF THE CONSISTENCY OF THE PULP FIBRES DURING HEAT TREATMENT

Consistency of pulp fibres during heat treatment (%)		Thermomechanical Pulp[1] Untreated	5	10	20	25
Pulp and Fibre Properties						
Curl Index		0.121	0.169	0.154	0.233	0.243
CSF (ml)		181	255	217	281	302
Wet-Web Properties						
0.7 kPa	Solids (%)	18.9	24.9	19.4	21.9	22.0
	Tensile (m)	91.5	93.6	90.6	59.1	62.3
	Stretch (%)	6.32	10.8	9.28	16.5	17.6
	Work to rupture (mJ/g)	69.0	137	108	119	129
103 kPa	Solids (%)	25.6	26.4	25.7	26.3	25.3
	Tensile (m)	161	134	153	98.8	101
	Stretch (%)	4.82	9.52	7.84	14.0	16.8
	Work to rupture (mJ/g)	90.8	163	148	174	208
Wet-web stretch at 100 m breaking length (%)		5.90	10.36	9.12	13.7	16.9

[1] Refined at 8.09 MJ/kg and 30% consistency

TABLE IV (Sheet 2)

THE EFFECT OF THE CONSISTENCY OF THE PULP FIBRES DURING HEAT TREATMENT

Consistency of pulp fibres during heat treatment (%)		High-Yield Sulphite Pulp (90% Yield)[2]				
		Untreated	5	10	20	25
Pulp and Fibre Properties						
Curl Index		0.128	0.163	0.181	0.201	0.216
CSF (ml)		338	414	390	403	429
Wet-Web Properties						
0.7 kPa	Solids (%)	22.5	21.3	21.7	19.8	19.3
	Tensile (m)	69.5	69.3	62.3	63.0	64.5
	Stretch (%)	4.98	5.94	8.09	12.8	14.3
	Work to rupture (mJ/g)	39.0	47.2	65.0	95.3	118
103 kPa	Solids (%)	26.4	27.5	24.5	22.7	23.2
	Tensile (m)	128	128	103	100	102
	Stretch (%)	3.38	4.22	5.47	11.3	12.2
	Work to rupture (mJ/g)	49.2	69.7	71.8	155	169
Wet-web stretch at 100 m breaking length (%)		3.96	5.16	6.21	10.3	11.1

2 Refined at 5.89 MJ/kg and 17% consistency

TABLE V (Sheet 1)

THE EFFECT OF THE HEAT TREATMENT ON THE WET-WEB AND DRY HANDSHEET PROPERTIES OF HIGH-YIELD PULPS

		78% Yield Sulphite Pulp Refined at 2.20 MJ/kg and 17% consistency		70% Yield Sulphite Pulps Refined at 0.64 MJ/kg and 30% consistency	
		Untreated	Heat treated	Untreated	Heat treated
Pulp and fiber properties					
	Curl index	0.169	0.220	0.147	0.237
	CSF/ml	236	326	685	601
Wet-Web properties					
0.7 kPa	solids (%)	20.6	19.2	27.4	24.3
	tensile (m)	144	111	74.0	91.6
	stretch (%)	6.38	16.2	2.10	17.8
	work to rupture (MJ/g)	116	244	16.2	189
103 kPa	solids (%)	28.3	24.6	31.1	28.6
	tensile (m)	283	183	124	124
	stretch (%)	5.04	12.3	2.00	12.2
	work to rupture (MJ/g)	162	286	26.3	203
Wet-Web stretch at 100 m breaking length (%)		8.0	17.7	2.21	15.3
Dry handsheet properties					
Bulk (cm^3/g)		1.54	1.66	1.86	1.57
Burst index ($kPa.m^2/g$)		6.96	5.58	5.81	4.56
Tear index ($mN.m^2/g$)		6.33	9.98	8.76	9.85
Breaking length (m)		10204	7991	8750	7159
Stretch (%)		2.89	3.71	2.68	3.20
Toughness index (mJ)		177	272	139	138
Zero-span b.l. (km)		14.38	14.05	15.79	14.56
Scattering coeff. (cm^2/g)		177	234	212	200
Tappi opacity (%)		70.4	91.7	76.1	73.0
Iso-Brightness (%)		42.8	35.3	44.6	41.4
Absorption coeff. (cm^2/g)		13.33	21.19	15.47	16.44

TABLE V (Sheet 2)

THE EFFECT OF THE HEAT TREATMENT ON THE WET-WEB AND DRY HANDSHEET PROPERTIES OF HIGH-YIELD PULPS

		70% Yield Sulphite Pulps			
		Refined at 0.78 MJ/kg and 24% consistency		Refined at 0.57 MJ/kg and 9% consistency	
		Untreated	Heat treated	Untreated	Heat treated
Pulp and fiber properties					
	Curl index	0.138	0.227	0.148	0.216
	CSF/ml	662	627	673	624
Wet-Web properties					
0.7 kPa	solids (%)	27.4	23.3	26.1	21.5
	tensile (m)	91.8	78.5	82.8	84.1
	stretch (%)	2.19	16.6	2.38	9.79
	work to rupture (MJ/g)	19.0	160	20.3	110
103 kPa	solids (%)	31.8	28.9	29.1	29.2
	tensile (m)	158	119	143	145
	stretch (%)	2.34	9.24	1.95	5.88
	work to rupture (MJ/g)	36.4	133	27.3	94.6
Wet-Web stretch at 100 m breaking length (%)		2.34	11.8	2.23	8.05
Dry handsheet properties					
Bulk (cm^3/g)		1.74	1.56	1.81	1.59
Burst index ($kPa.m^2/g$)		6.73	4.81	6.24	5.44
Tear index ($mN.m^2/g$)		8.26	10.07	8.22	8.71
Breaking length (m)		9422	7041	9704	8246
Stretch (%)		2.79	3.16	2.63	3.00
Toughness index (mJ)		159	138	150	131
Zero-span b.l. (km)		16.12	14.94	16.45	16.36
Scattering coeff. (cm^2/g)		208	208	219	211
Tappi opacity (%)		76.3	75.5	77.2	74.1
Iso-Brightness (%)		44.8	42.2	45.3	42.0
Absorption coeff. (cm^2/g)		14.88	16.24	14.68	16.51

pulp was sprayed with a solution of sodium carbonate to incr ase its pH to 10.0 and was also given a heat treatment at the same conditions.

Both heat treated pulps show remarkable improvement in wet-web properties and dry tear strength and stretch over the untreated sample (Table VI). The pulp heat treated at high pH has higher tear strength due to the protective action of the alkali which reduces the loss in fibre strength through acid hydrolysis.

EXAMPLE 7

This example illustrates the effect of pulp bleaching or brightening agents on the wet-web and dry-handsheet strength of heat treated pulps.

A 70% yield sulphite pulp was bleached by a conventional hydrogen peroxide treatment following the heat treatment at 150°C for 60 minutes and 20% consistency. Results are given in Table VII for the pulps after treatment with different peroxide charges and after a standard hot disintegration. The pulp after bleaching still possesses all the claimed superior properties (with the exception of drainage) resulting from the heat treatment done under the conditions disclosed in this invention.

EXAMPLE 8

As a further example pulps have been heat treated in the way described earlier, with the addition of a brightening agent during the heat treatment stage.

A thermomechanical pulp and a 70%-yield sulphite

TABLE VI

THE EFFECT OF THE PULP FIBRE pH DURING HEAT TREATMENT

	70% yield sulphite pulp[1]		
	Untreated pulp hot disintegrated	Heat treated pulp at 150°C for 60 minutes and 20% consistency followed by hot disintegration	
pH of heat treatment	-	3.2	10.0
Pulp and fibre properties			
Curl index	0.135	0.237	0.253
CSF (ml)	643	610	672
0.7 kPa solids (%)	25.4	22.1	26.7
tensile (m)	103	89.5	67.8
stretch (%)	2.67	15.8	7.38
work to rupture	25.1	157	52.6
103 kPa solids (%)	29.0	28.2	29.4
tensile (m)	169	141	103
stretch (%)	2.54	9.61	6.19
work to rupture	34.4	142	67.0
Wet-Web stretch at 100 m breaking length	2.89	13.5	6.24
Dry handsheet properties			
Bulk (cm^3/g)	1.72	1.54	1.78
Burst index ($kPa.m^2/g$)	6.70	4.71	1.78
Tear index ($mN.m^2/g$)	8.15	9.78	16.41
Breaking length (m)	9924	7383	5547
% stretch	2.89	3.03	2.99
Toughness index (mJ)	167	137	107
Zero-span b.l. (km)	16.38	14.95	14.35
Scattering coeff. (cm^2/g)	205	209	263
Tappi opacity (%)	74.6	74.9	93.7
Iso-brightness (%)	44.4	43.0	21.5
Absorption coeff. (cm^2/g)	14.86	15.22	50.50

[1] Refined at 0.99 mJ/kg and 18% consistency

TABLE VII (Sheet 1)

THE EFFECT OF BLEACHING HEAT-TREATED PULPS

		Before Heat Treatment	70% Yield Sulphite Pulp[1] After heat treatment at 150°C for 60 minutes and 20% consistency followed by peroxide bleaching			
Weight of Peroxide on Pulp (%)		-	0	0.5	1.0	2.0
Pulp and Fibre Properties						
	Curl Index	0.138	0.227	0.216	0.209	0.204
	CSF (ml)	662	607	583	533	524
Wet-Web Properties						
0.7 kPa	Solids (%)	27.4	23.3	22.9	25.0	22.7
	Tensile (m)	91.8	87.7	92.2	93.7	95.9
	Stretch (%)	2.19	15.1	12.8	14.0	16.5
	Work to rupture	19.0	150	131	165	210
103 kPa	Solids (%)	31.8	29.0	28.1	32.8	25.3
	Tensile (m)	158	133	139	180	151
	Stretch (%)	2.34	9.31	9.26	8.95	8.48
	Work to rupture	36.4	148	150	171	162
Wet-Web stretch at 100 m breaking length (%)		2.34	13.02	12.82	13.82	15.0

TABLE VII (Sheet 2)

THE EFFECT OF BLEACHING HEAT-TREATED PULPS

Dry Handsheet Properties	Before Heat Treatment	70% Yield Sulphite Pulp[1] After heat treatment at 150°C for 60 minutes and 20% consistency followed by peroxide bleaching			
Bulk (cm^3/g)	1.74	1.54	1.53	1.47	1.49
Burst Index ($kPa.m^2/g$)	6.73	4.50	4.70	5.23	5.18
Tear Index ($mN.m^2/g$)	8.26	10.40	10.75	10.64	10.04
Breaking Length (m)	9422	6754	6814	7389	7302
Stretch (%)	2.79	3.26	3.43	3.50	3.48
Toughness Index (mJ)	159	143	148	170	163
Zero-span b.l. (km)	16.12	14.38	14.42	14.48	14.98
Scattering Coeff. (cm^2/g)	208	211	206	196	198
Tappi Opacity (%)	76.3	76.8	61.5	68.7	66.4
Iso-Brightness (%)	44.8	42.1	49.3	52.9	56.6
Absorption Coeff. (cm^2/g)	14.88	16.36	7.02	5.23	4.03
Visual Efficiency (%)	56.0	53.6	63.5	67.0	70.5
Printing Opacity (%)	86.0	86.6	69.6	77.0	73.7

[1] Refined at 0.78 MJ/kg and 24% consistency

pulp at about 30% consistency were sprayed with a solution of 2% H_2O_2, 0.4% EDTA, 3% $Na_2S_iO_3$, 0.005% $MgSO_4$, to bring it to 19% consistency. The pulps were treated at 150°C for 10 minutes.

Results are given in Table VIII. Both pulps are higher in visual efficiency than the control and possess all the other desired superior properties.

EXAMPLE 9

This example illustrates the effect of the heat treatment on bleached or brightened pulps.

A 70% yield sulphite pulp and a thermomechanical pulp at about 30% consistency were sprayed with a solution of 2% H_2O_2, 0.4% EDTA, 3% Na_2SiO_3 and 0.005% $MgSO_4$ to bring it to 19% consistency. The pulps reacted with the chemicals for one hour at 60°C. Afterwards, the pulps were heat treated at 150°C for 10 minutes.

Results are given in Table IX for the original pulps before heat treatment, the brightened pulps and for both pulps after heat treatment. The heat treatment, done under the conditions disclosed herein on the brightened pulp compared to the original pulp gave similar properties while it had higher visual efficiency.

TABLE VIII (Sheet 1)

THE EFFECT OF THE ADDITION OF A BRIGHTENING AGENT TO PULP DURING THE HEAT TREATMENT

		70% YIELD SULPHITE PULP[1]			TMP[2]		
			Heat Treatment at 150°C, 10 min, 19% consistency with			Heat Treatment at 150°C, 10 min, 19% consistency with	
Pulp and Fibre Properties		Before Heat Treatment	No Bleaching Chemicals	2% H_2O_2 0.4% EDTA 3% Na_2SiO_3 0.005% $MgSO_4$	Before Heat Treatment	No Bleaching Chemicals	2% H_2O_2 0.4% EDTA 3% Na_2SiO_3 0.005% $MgSO_4$
	Curl Index	0.148	0.187	0.209	0.106	0.177	0.163
	CSF (ml)	673	651	685	175	312	293
Wet-Web Properties							
0.7 kPa	Solids (%)	26.1	26.5	25.1	20.6	25.9	23.4
	Tensile (m)	82.8	92.4	80.1	110	86.1	96.1
	Stretch (%)	2.38	3.32	5.04	5.02	10.1	10.1
	Work to rupture	20.3	32.0	43.7	68.4	117	122
103 kPa	Solids (%)	29.1	32.5	32.1	25.0	32.3	29.3
	Tensile (m)	143	147	127	167	144	150
	Stretch (%)	1.95	2.53	3.49	4.42	8.22	7.24
	Work to rupture	27.3	38.1	44.7	86.8	159	144
Wet-Web stretch at 100 m breaking length (%)		2.23	2.90	4.05	5.22	9.61	8.93

TABLE VIII (Sheet 2)

THE EFFECT OF THE ADDITION OF A BRIGHTENING AGENT TO PULP DURING THE HEAT TREATMENT

	70% YIELD SULPHITE PULP[1]			TMP[2]		
		Heat Treatment at 150°C, 10 min, 19% consistency with			Heat Treatment at 150°C, 10 min, 19% consistency with	
Dry Handsheet Properties	Before Heat Treatment	No Bleaching Chemicals	2% H_2O_2 0.4% EDTA 3% Na_2SiO_3 0.005% $MgSO_4$	Before Heat Treatment	No Bleaching Chemicals	2% H_2O_2 0.4% EDTA 3% Na_2SiO_3 0.005% $MgSO_4$
Bulk (cm^3/g)	1.81	1.65	1.79	2.79	3.10	2.96
Burst Index ($kPa.m^2/g$)	6.24	5.78	4.38	2.02	1.36	1.50
Tear Index ($mN.m^2/g$)	8.22	7.84	7.84	8.72	8.27	8.94
Breaking Length (m)	9704	9251	7361	3625	2469	2792
Stretch (%)	2.63	2.71	2.32	2.15	2.05	2.07
Toughness Index (mJ)	150	156	113	45	32	37
Zero-span b.l. (km)	16.45	16.23	13.96	11.20	9.78	10.47
Scattering Coeff. (cm^2/g)	219	203	238	568	568	581
Tappi Opacity (%)	77.2	76.1	79.7	93.8	95.1	93.3
Iso-Brightness (%)	45.3	41.7	42.8	56.0	50.9	55.8
Absorption Coeff. (cm^2/g)	14.68	15.10	9.22	20.23	20.49	9.83
Visual Efficiency (%)	56.6	54.3	60.4	67.3	64.4	71.2

Refined at 0.57 MJ/kg and 9% consistency
Refined at 8.52 MJ/kg and 35% consistency after second stage

TABLE IX. THE EFFECT OF THE HEAT TREATMENT ON BLEACHED OR BRIGHTENED PULPS (Sheet 1)

Pulp and Fibre Properties	70% YIELD SULPHITE PULP[1]			
	(a) Original Pulp Before Heat Treatment	(b) Pulp (a) Brightened	Heat Treatment at 150°C, 10 min.	
			Original Pulp (a)	Brightened Pulp (b)
Curl Index	0.108	0.157	0.215	0.223
CSF (ml)	715	687	681	707
Wet-Web Properties				
0.7 kPa Solids (%)	26.8	26.3	27.7	28.0
Tensile (m)	77.2	79.8	59.1	62.5
Stretch (%)	1.71	1.77	2.99	3.49
Work to rupture	14.5	12.0	20.3	23.6
103 kPa Solids (%)	33.5	31.5	29.2	30.5
Tensile (m)	160	119	100	89.4
Stretch (%)	1.63	1.73	2.49	2.84
Work to rupture	27.7	17.3	26.4	29.2
Wet-Web stretch at 100 m breaking length (%)	1.81	1.74	3.02	2.74
Dry Handsheet Properties				
Bulk (cm^3/g)	1.87	1.80	1.68	1.80
Burst Index ($KPa.m^2/g$)	6.09	6.17	5.01	4.35
Tear Index ($mN.m^2/g$)	7.99	7.35	8.54	7.48
Breaking Length (m)	9054	10033	7675	7300
Stretch (%)	2.62	2.60	2.85	2.50
Toughness Index (mJ)	128	146	131	109
Zero-span b.l. (km)	15.68	16.39	15.43	13.80
Scattering Coeff. (cm^2/g)	221	220	215	241
Tappi Opacity (%)	73.8	69.1	75.3	73.8
Iso-Brightness (%)	46.5	53.2	42.2	46.5
Absorption Coeff. (cm^2/g)	13.79	4.90	13.85	6.14
Visual Efficiency (%)	57.9	68.9	55.2	65.2
Printing Opacity (%)	83.6	76.6	85.1	81.7

[1] Refined at 0.50 MJ/kg and 15% consistency

TABLE IX. THE EFFECT OF THE HEAT TREATMENT ON BLEACHED OR BRIGHTENED PULPS (Sheet 2)

Pulp and Fibre Properties		TMP[2]			
		(a) Original Pulp Before Heat Treatment	(b) Pulp (a) Brightened	Heat Treatment at 150°C, 10 min. Original Pulp (a)	Heat Treatment at 150°C, 10 min. Brightened Pulp (b)
	Curl Index	0.106	0.113	0.177	0.167
	CSF (ml)	175	187	312	308
Wet-Web Properties					
0.7 kPa	Solids (%)	20.6	21.1	25.9	21.5
	Tensile (m)	110	105	86.1	82.5
	Stretch (%)	5.02	5.44	10.1	11.3
	Work to rupture	68.4	71.9	117	114
103 kPa	Solids (%)	25.0	27.5	32.3	26.4
	Tensile (m)	167	157	144	129
	Stretch (%)	4.42	4.75	8.22	8.38
	Work to rupture	86.8	94.9	159	124
Wet-Web stretch at 100 m breaking length (%)		5.22	5.54	9.61	10.0
Dry Handsheet Properties					
Bulk (cm^3/g)		2.79	2.78	3.10	2.94
Burst Index ($KPa.m^2/g$)		2.02	2.07	1.36	1.43
Tear Index ($mN.m^2/g$)		8.72	8.92	8.27	8.34
Breaking Length (m)		3625	3814	2469	2713
Stretch (%)		2.15	2.13	2.05	1.95
Toughness Index (mJ)		45	47	32	33
Zero-span b.l. (km)		11.20	11.08	9.78	9.92
Scattering Coeff. (cm^2/g)		568	555	568	570
Tappi Opacity (%)		93.8	87.7	95.1	91.8
Iso-Brightness (%)		56.0	67.8	50.9	56.6
Absorption Coeff. (cm^2/g)		20.23	3.91	20.49	8.95
Visual Efficiency (%)		67.3	81.1	64.4	72.0
Printing Opacity (%)		96.2	89.7	97.1	94.5

Among the features of the method for treating pulp fibres as described above which are preferred features and may be made the subject of further claims in this application are the following:

1. A method wherein the pulp fibres are lignocellulosic pulp fibres obtained after a single stage refining, or, after two successive refinings, or, between two successive refinings.

2. A method wherein the pulp fibres are lignocellulosic pulp fibres at neutral or alkaline pH.

3. A method wherein the pulp fibres are pulp fibres commercially produced under the designation of refiner mechanical pulp, pressurised refiner mechanical pulp and thermomechanical pulp either from a single stage or two-stage refining.

4. A method wherein the pulp fibres are pulp fibres commercially produced under the designation of ultra-high-yield pulps, high-yield pulps, high-yield chemi-thermomechanical pulps, chemimechanical pulps, interstage thermomechanical pulps and chemically post treated mechanical or thermomechanical pulps.

5. A method wherein the pulp fibres are part of the furnish.

6. A method wherein the pulp fibres are the refined rejects in mechanical or high yield pulp production.

7. A method wherein the pulp fibres are whole pulps of the furnish.

8. A method including the step of incorporating a brightening agent during heat treatment, to upgrade the brightness while retaining the improved pulp properties.

9. A method including the subsequent steps of brightening or bleaching sequences to upgrade the brightness of the pulpswhile maintaining the improved pulp properties.

10. A method wherein the pulps are brightened pulps, thereby to maintain adequate brightness after heat treatment as well as the improved pulp properties.

CLAIMS:

1. A method for treating pulp fibres, that have already been curled which method comprises: subjecting said pulp fibres to a heat treatment while said pulp is at a high consistency in the form of nodules or entangled mass, thereby to render said curl permanent to subsequent mechanical action.

2. A method for treating pulp fibres, that have already been curled by a high consistency action, which method comprises: subjecting said pulp fibres to a heat treatment at a temperature of at least 100°C, while said pulp is in the form of nodules or entangled mass at a consistency of at least 5% thereby to render said curl permanent to subsequent mechanical action.

3. A method for treating pulp fibres that have already been curled by a high consistency action, which method comprises: subjecting said pulp fibres to a heat treatment at a temperature of 100°C-170°C for a period of time of at least 2 minutes, while said pulp, in the form of nodules or entangled mass is at a consistency of at least 5%, preferably 15% or more, thereby to render said curl permanent to subsequent mechanical action.

4. The method of claims 1, 2 or 3 wherein said heat treatment is carried out as a batch method, in a digester.

5. The method of claims 1, 2 or 3 wherein said heat treatment is carried out as a continuous method through a steaming tube maintained at high pressure.

6. The method of claims 1, 2 or 3 wherein said pulp fibres are lignocellulosic pulp fibres produced by mechanical defibration.

7. The method of claims 1, 2 or 3 wherein ~~said pulp~~ fibres are lignocellulosic pulp fibres produced by refining.

8. The method of claims 1, 2 or 3 wherein said pulp fibres are lignocellulosic pulp fibres produced by refining in a disc refiner at high consistency, and/or in a device such as, but not exclusively, a "Curlator" or a "Frotopulper", which introduces curl and kinks in the fibres.

9. The method of claims 1, 2 or 3 wherein said pulp fibres are lignocellulosic pulp fibres produced by mechanical defibration of wood chips at high consistency.

10. The method of claims 1, 2 or 3 wherein said pulp fibres are lignocellulosic pulp fibres produced by mechanical defibration of wood chips at high consistency followed or preceded by a chemical treatment.